Space Weather Technical Forecast

Issued on Monday, 25 September 2023 at 01:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Isolated M-flares likely, with a slight chance of X-flares (R1-R3 Radio blackouts). G1-G2 minor/moderate geomagnetic storms likely day 1 (25 Sep) with a slight chance of G3/Strong storms.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with a single M-flare observed in the past 24hrs, peaking at M4.4 at 24/0328 UTC from the AR3445 region in the southeast. Frequent C-flares were also observed, some long lasting. AR3445 was the most active and developmental region on the disc, with ongoing flux emergence leading to a small delta spot developing. There are a total of ten sunspot regions on the disc, with AR3443 in the northwest and AR3435 in the north-centre disc persisting as moderately sized regions, although less active than recent days. Despite this AR3435 remains notable as an anti-Hale cycle spot, while AR3443 maintained some slight complexity with a small reverse polarity region following its main trailer spots.

A filament eruption over the NW limb has been observed, with a CME seen on early imagery. This is unlikely to be Earth-directed, pending further analysis. No other Earth-directed CMEs have been observed in the past 24hrs.

Solar Wind / Geomagnetic Activity: Slow wind conditions persisted for much of the day before a CME arrived late on 24 Sep. Speeds increased from background to slow ambient, 300 km/s becoming 470 km/s. The density followed a similar pattern, rising from below average to briefly well above average, with a peak of around 60 ppcc at 24/2033 UTC. The Interplanetary magnetic field strength (IMF), Bt, was initially weak before becoming strong, around 28nT at 24/2043 UTC. The north-south component (Bz) also rose from weak to negatively strong, peaking at -28nT at 24/2043 UTC. Phi angle was predominantly positive (away from the Sun), then became predominantly negative after 24/2000 UTC. Resultant geomagnetic activity was Quiet to Unsettled (Kp 1-3) with a G1/Minor Storm (Kp5) interval between 24/1800-2100 UTC then a G2/Moderate storm interval between 24/2100-2400 UTC.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at background to moderate levels. GOES16 high energy (greater than 2MeV) electron flux was moderate until 24/2045 UTC when it became background due to a CME arrival. Associated 24-hour fluence was below the Active (1e8 integrated pfu) threshold and on a declining trend. The observation at 24/0001 UTC was 1.4e7.

Four-Day Space Weather Forecast Summary

Solar Activity: Forecast to persist at Moderate with further isolated M-flares likely, and a slight chance of rising to High due to the potential for isolated X-flares from AR3445 in the southeast.

Solar Wind / Geomagnetic Activity: Ongoing impacts from a CME arrival on 24 Sep remain likely through the first part of day 1 (25 Sep). Further CME arrivals are possible into day 2 (26 Sep). Confidence is low however, with a glancing impacts most likely. The slightly elevated solar winds are expected to continue through day 1 (25 Sep), likely easing thereafter to slow ambient.

Geomagnetic activity is likely to remain enhanced initially with G1/Minor or G2/Moderate storming and a chance of G3/Strong storm intervals during the first part of day 1. Geomagnetic

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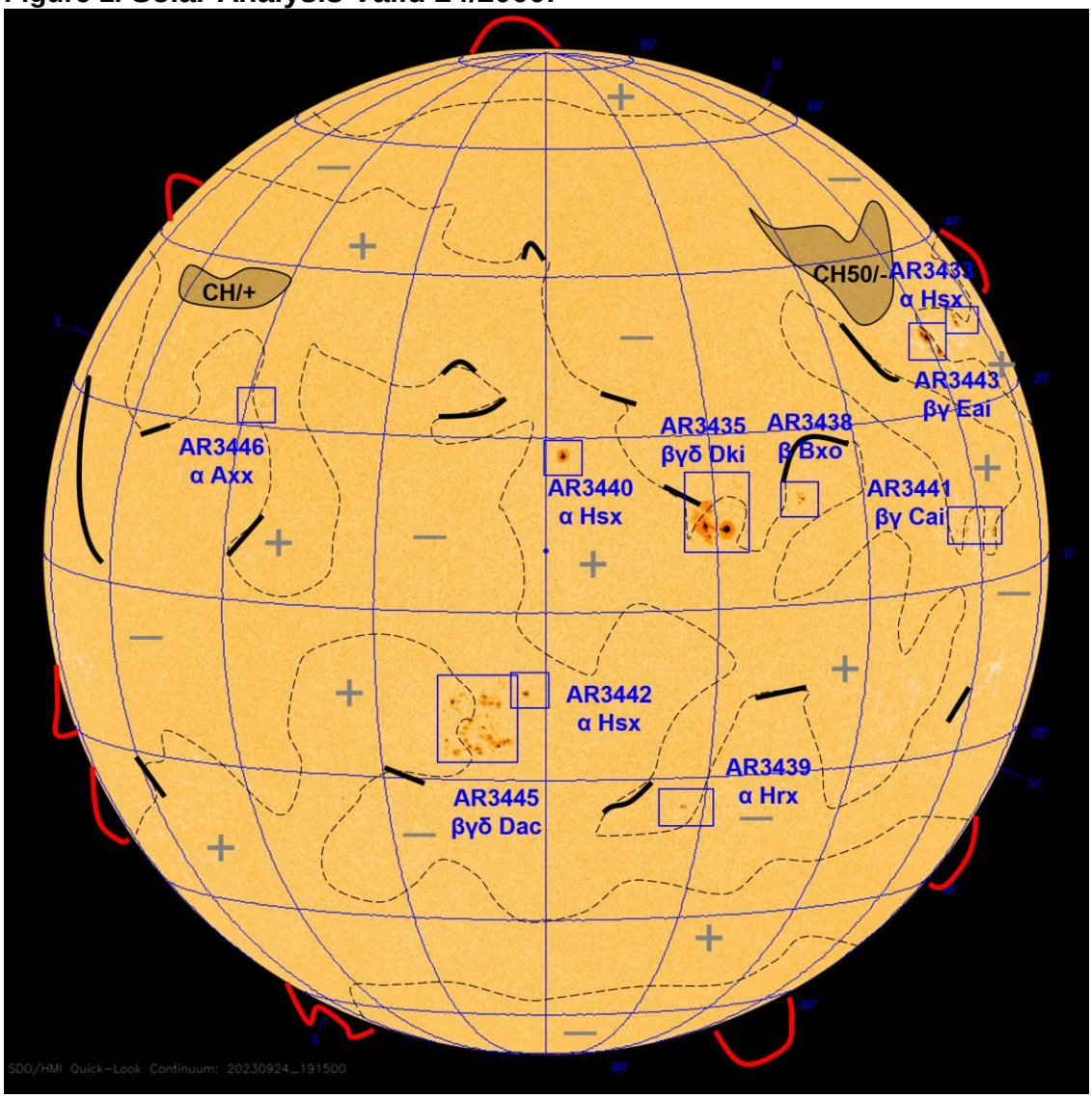
activity will then likely reduce back to Unsettled to Active with a chance of G1/Minor storm intervals should any subsequent glancing CMEs occur into day 2 (26 Sep). Quiet to Unsettled activity is then expected dominate toward the end of the forecast period.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is expected to remain at Background levels, with a daily slight chance of an enhancement should any larger flares occur.

High energy electron flux (greater than 2MeV) has become background due to a CME arrival on 24 Sep. Further CME glancing blows may continue this trend, though confidence reduces later in the period with a chance or returning to high by day 4 (28 Sep). The associated 24 hour fluence is in a declining phase and will likely remain below the Active threshold until at least day 4 (28 Sep), though any increase is low confidence.

Figure 1. Solar Analysis Valid 24/2000.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The geomagnetic forecast is currently low confidence due to the number of CME's that have recently left the Sun. The CME associated with the LP M1.2 flare, from 22/0336 UTC is thought to have arrived late 24 Sep, this may have swept up and combined with other CMEs from 20 Sep and 21 Sep. Ongoing impacts from this arrival is expected during 25 Sep.

There remains the potential for further arrivals from two further CMEs from early on 22 Sep. The first south of the AR3435/38 complex spot and a further one to the north of this region. These are both weak eruptions but give a slight chance of further enhancements on 25/26 Sep but these are very low confidence. Other CMEs which feature in the forecast are from the double peak M1.5/1.4 flare at 22/1621 UTC and 22/1714 UTC of AR3443 in the northwest and from the M1.9 flare at 22/2300 UTC from AR3435/38. These CMEs are currently expected to be missing Earth but may give slight glancing impacts, potentially combined within the material in the aforementioned CMEs.

There are further CMEs still awaiting analysis from 24 Sep.

Overall this gives a very low confidence geomagnetic forecast, with potential for it to range from successive CMEs arrivals, giving Minor to Moderate geomagnetic storming (most likely Day 1, 24 Sep) to Quieter conditions with solar winds dominated by slightly elevated or background slow winds, or any weak interaction with the fast winds of CH50/-. Although, having yet to occur, any connection to the HSS from these feature is now expected to be limited.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	70	30	20	5
Strong	G3	No	10	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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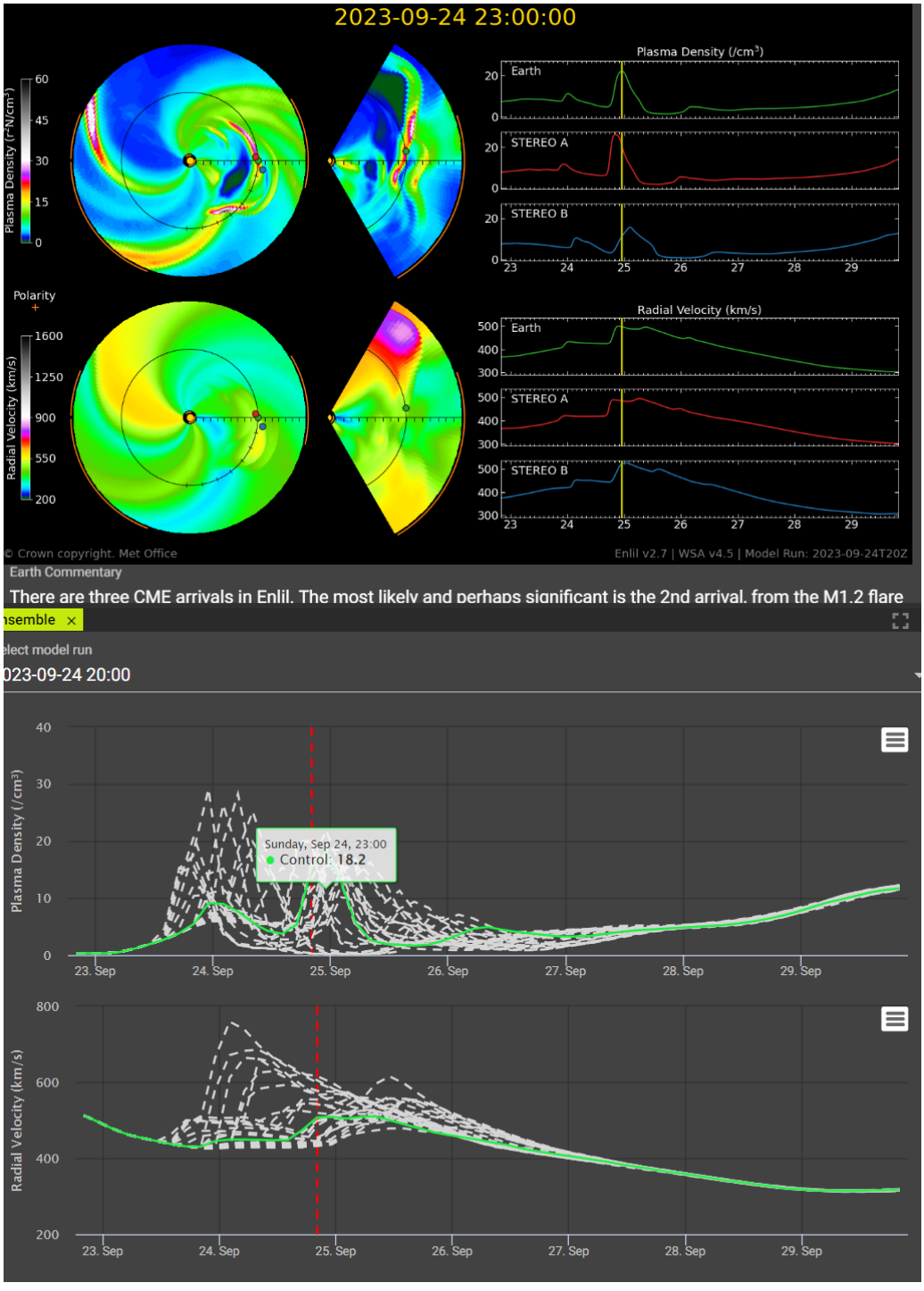
Figure 2: ENLIL and Ensemble.



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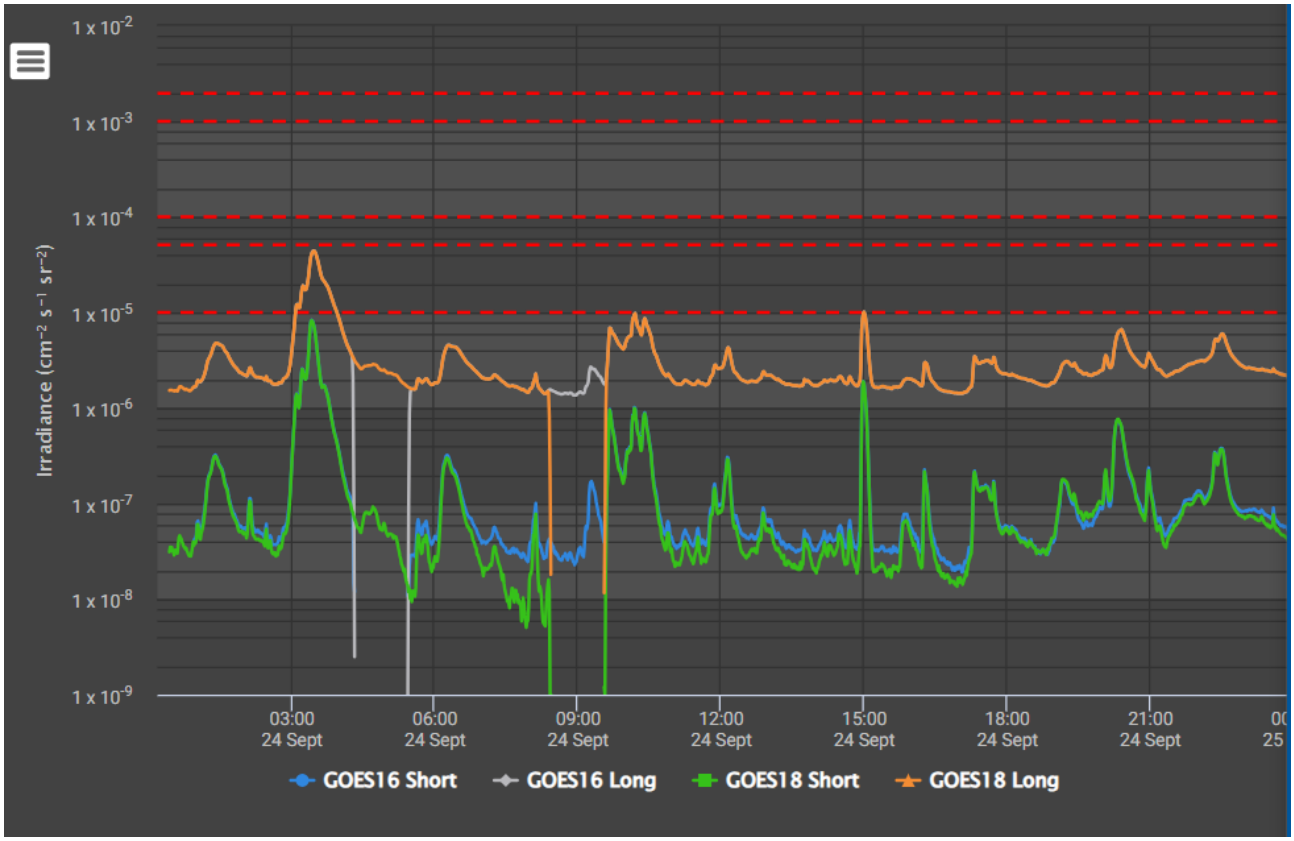
Radio Blackouts - X-Ray Flares:

Moderate activity is expected with an ongoing likelihood of further M-flares through the period, and a slight chance of rising to High with the potential for isolated X-flares. This is due to the current number of spots (ten) and the complexity of at least two.

AR3445 in the southeast quadrant has a small mixed polarity region, resulting in an potentially unstable delta configuration. AR3435 and AR3443 both remain larger regions, and were both sources of activity in the past 48hrs. AR3435 in the northwest quadrant remains the only notable spot of these two, with a delta spot in its northern portion.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	70	70	60	60
Very Active	R3 to R5 X Class	No	20	20	15	10

Figure 3: 24 hour xray trace



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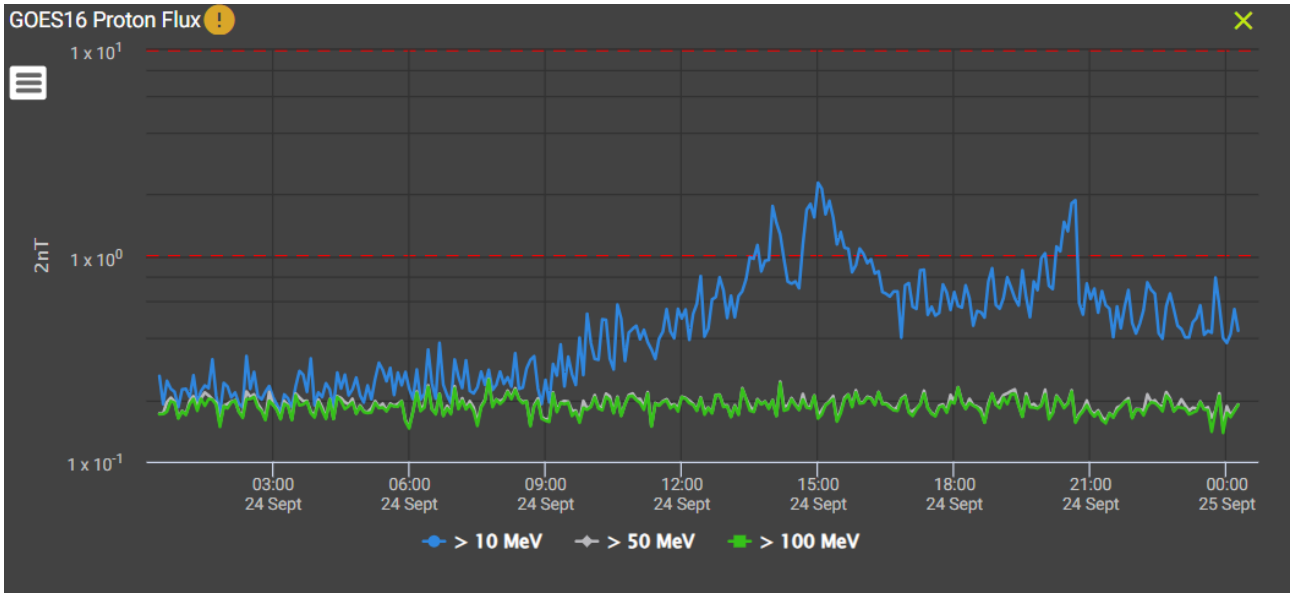
Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is likely to persist at background to moderate levels, however there are regions either on, or moving onto the western disc which bring a chance of flux levels rising above background given the occurrence of any significant flares. This includes AR3433 and AR3435, as well as AR3445 in the southeast.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: 24 hour proton trace



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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) observed by GOES16 has been largely moderate, as enhanced electron levels at lower orbits expand outward to GEO. The CME arrival on 24 Sep has since reduced electron counts and is likely to continue to do so through day 1 and perhaps into day 2 (25/26 Sep). Further CME glancing blows may continue this trend, though confidence reduces later in the period with a chance or returning to high by day 4 (28 Sep).

The associated 24 hour fluence is in a declining phase and will likely remain below the Active threshold until at least day 4 (28 Sep), though any increase is low confidence. REFM is currently giving good guidance of the expected trend, remaining below Active throughout.

GEO Electron Environment	Level ($cm^{-2}\ sr^{-1}\ day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	5	10	20	30
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: Electron flux and REFM model

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